US009636630B2

(12) **United States Patent**
Evosevich et al.

(10) **Patent No.: US 9,636,630 B2**
(45) **Date of Patent: *May 2, 2017**

(54) **GAS SEPARATION SYSTEMS AND METHODS USING MEMBRANES**

(71) Applicant: **The Boeing Company**, Hungtington Beach, CA (US)

(72) Inventors: **Barbara J Evosevich**, Fullerton, CA (US); **Ivana Jojic**, Bellevue, WA (US)

(73) Assignee: **THE BOEING COMPANY**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 260 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/512,818**

(22) Filed: **Oct. 13, 2014**

(65) **Prior Publication Data**

US 2015/0027305 A1 Jan. 29, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/665,767, filed on Oct. 31, 2012, now Pat. No. 8,882,886.

(51) **Int. Cl.**
B01D 53/22 (2006.01)
B64D 37/32 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B01D 53/226*** (2013.01); ***B01D 63/00*** (2013.01); ***B01D 63/02*** (2013.01); ***B01D 69/02*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B01D 53/226; B01D 63/00; B01D 63/02; B01D 69/02; B01D 69/08;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,479,766 A 8/1949 Mulvany
4,704,139 A 11/1987 Yamamoto et al.
(Continued)

FOREIGN PATENT DOCUMENTS

WO WO0000389 1/2000
WO WO2005115123 12/2005
(Continued)

OTHER PUBLICATIONS

State Intellectual Property Office of PRC; Office Action issued in CN Patent Application No. 201380050974.4; dated Mar. 24, 2016, 18 pages.
(Continued)

Primary Examiner — Anthony Shumate
(74) *Attorney, Agent, or Firm* — Parsons Behle & Latimer

(57) **ABSTRACT**

A gas separation method includes contacting a membrane filter with gas feed, permeating the gas from the gas feed through the membrane, and producing filtered gas from the filter. The filtered gas is produced from the filter as a result of the membrane removing any hydrocarbons containing six or more carbon atoms to produce a total of 0.001 ppm w/w or less. A gas separation method includes feeding gas into a filter containing a hollow fiber membrane that exhibits the property of resisting degradation due to exposure to hydrocarbons containing six or more carbon atoms. The filter exhibits a pressure drop across the membrane of less than 5 psi. The method includes feeding the filtered gas into a gas separation module that exhibits a susceptibility to degradation from exposure to hydrocarbons containing six or more carbon atoms.

18 Claims, 1 Drawing Sheet